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**Workshop:**  
**“Ammonia as Energy Carrier” (PART II)**  
organized by



# Ammonia based membrane reactor for green Hydrogen production

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# I. Main goal



The ANDREAH project aims at providing a quantum leap in the development of **advanced ammonia decomposition technologies** to produce **ultra-pure hydrogen (>99.998%)** by developing an innovative system based on a **Catalytic Membrane Reactor (CMR)** for the **cracking of Ammonia**.

- Designing and setting up a broad and complete **network of value chains**.
- Developing a set of flexible **cost-effective and environmentally friendly technologies** that can be easily tailored for the decomposition of ammonia into green H<sub>2</sub> for different applications (Energy & Transport among others).
- **Laying the foundations for new business opportunities** related to the development of new catalysts and membranes integrated into membrane reactors to provide huge process intensification enabling the **distributed generation of hydrogen from NH<sub>3</sub> as long-term storage media**.

ANDREAH will work through a holistic approach to tackle both the centralized and decentralized hydrogen generation from ammonia and develop a flexible and efficient ammonia cracking technology able to satisfy the decarbonization of hard to abate sectors.



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# I. Main goal and specific targets



- I. To develop and demonstrate at **10 kgH<sub>2</sub>/day scale**, a new **Intensified ammonia cracking system based on Catalytic membrane Reactor Technology** through advanced Carbon Molecular Sieve Membranes integrated with Novel Catalyst .
  - To develop an innovative, environmentally friendly and with less critical materials, **structured catalyst** that can be used at much lower temperatures compared to state-of-the-art process.
    - catalysts **without or with low (<1wt%) Ru content** (using not critical Ni) capable of **operating at temperatures 400-450 °C**.
    - To design and manufacture **highly conductive 3D printed Periodic Open Cellular Structures (POCS)** with optimised heat and mass transfer.
  - To develop **innovative membranes for selective separation of H<sub>2</sub>** during production process.
  - To develop **novel sorbents for polishing the H<sub>2</sub>** recovered by the membranes.

# I. Main goal and specific targets

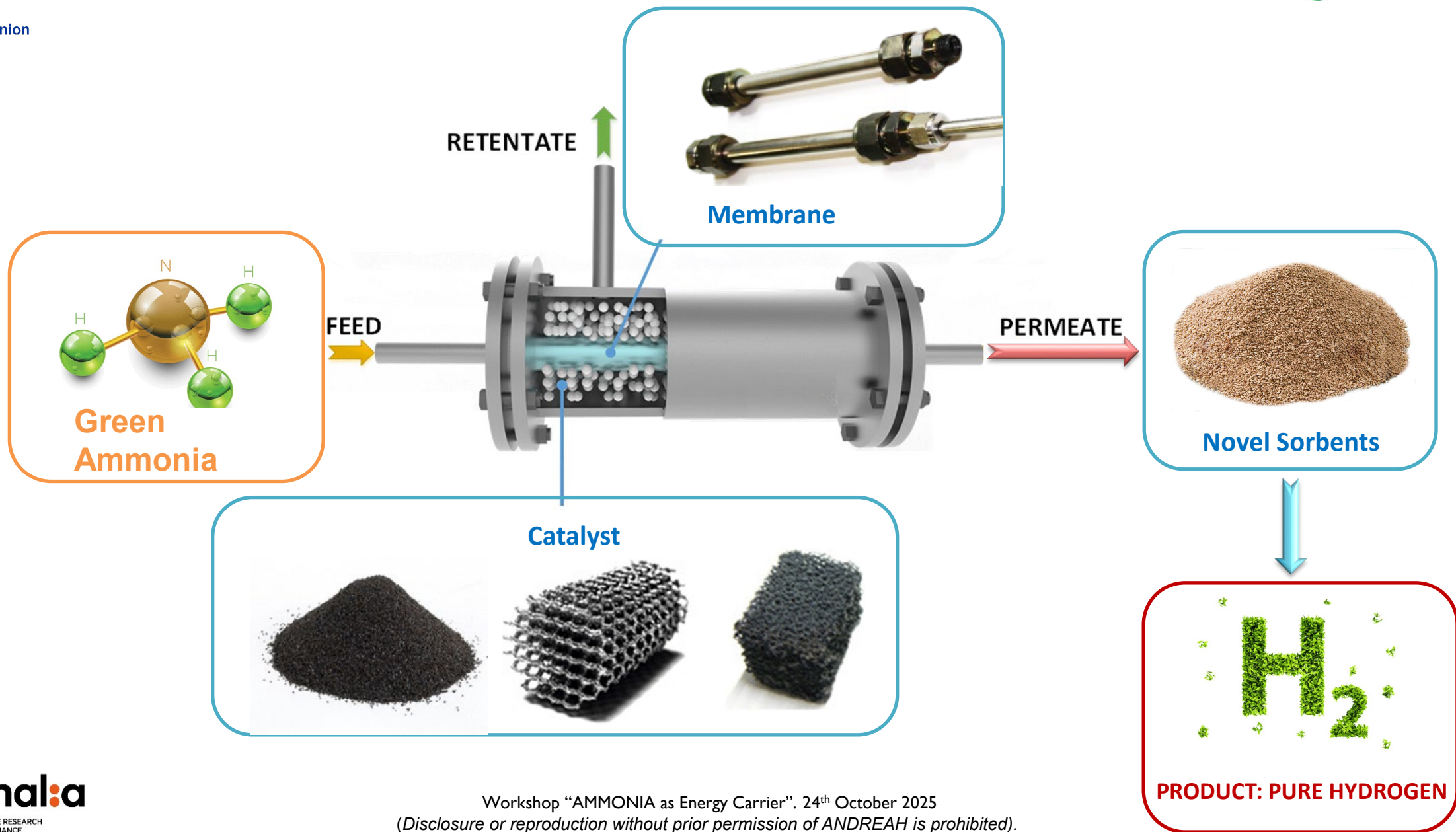
2. To develop a full **LCA, LCC and Health and Safety Analysis (HSE)** of ANDREAH project.
3. To pave the way for future exploitation of ANDREAH Key Exploitable results .
  - To elaborate the **business case of KERI**. Advanced catalysts, sorbents and membranes integrated into a CMR for ammonia cracking.
4. To promote the **dissemination and communication** of ANDREAH's results and expand its impact.



# 2. Overall approach and methodology



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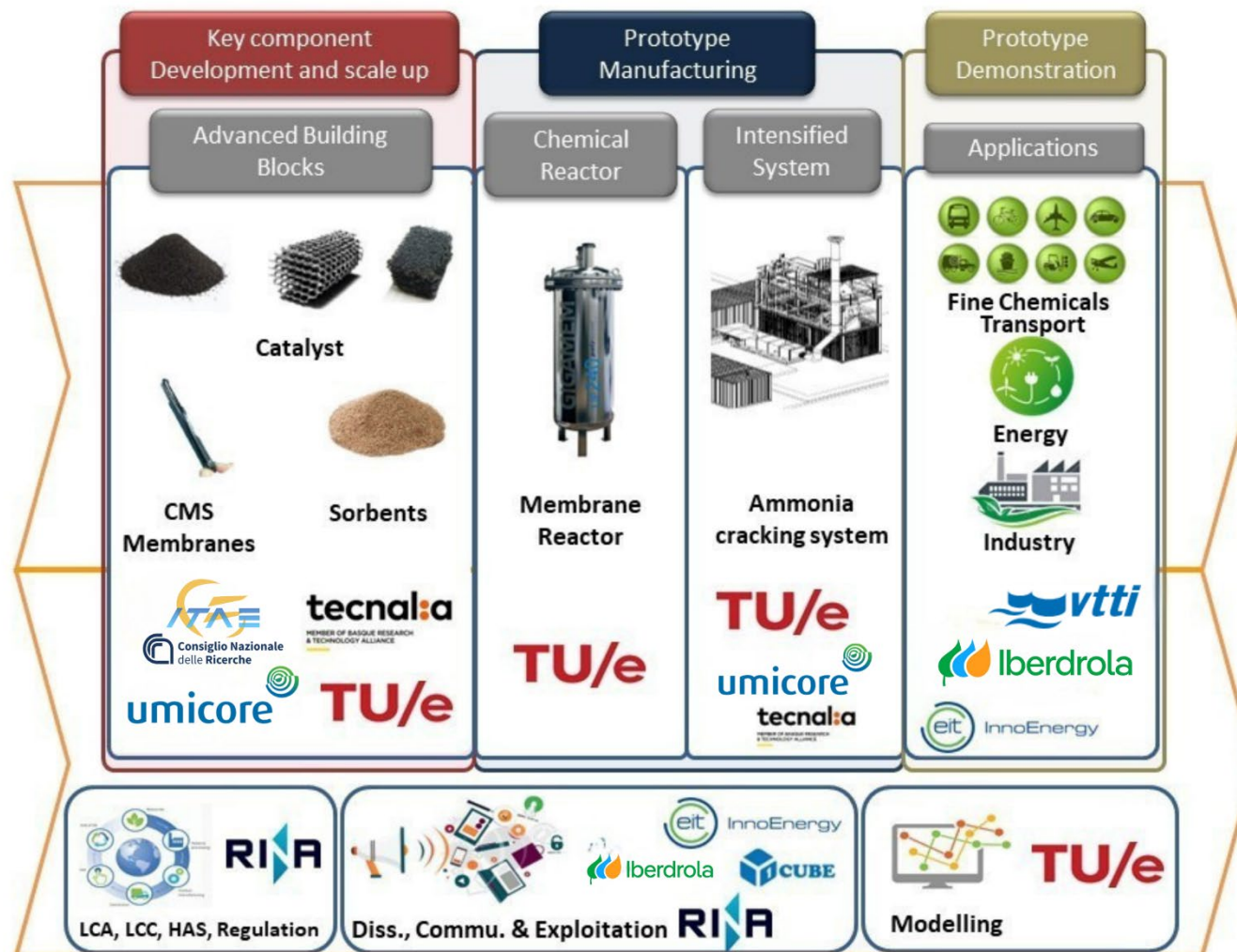




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# 2. Overall approach and methodology

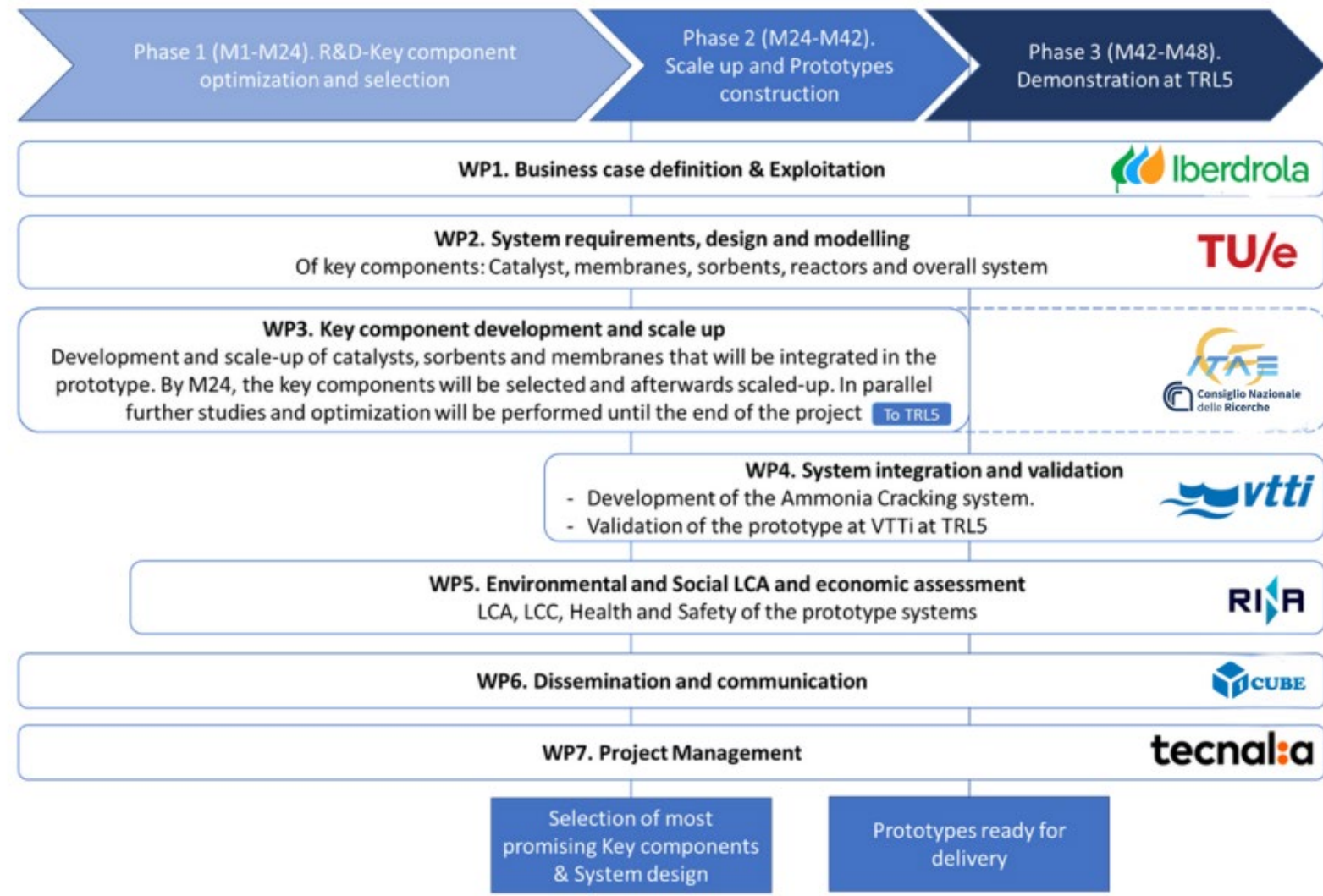




# 2. Overall approach and methodology



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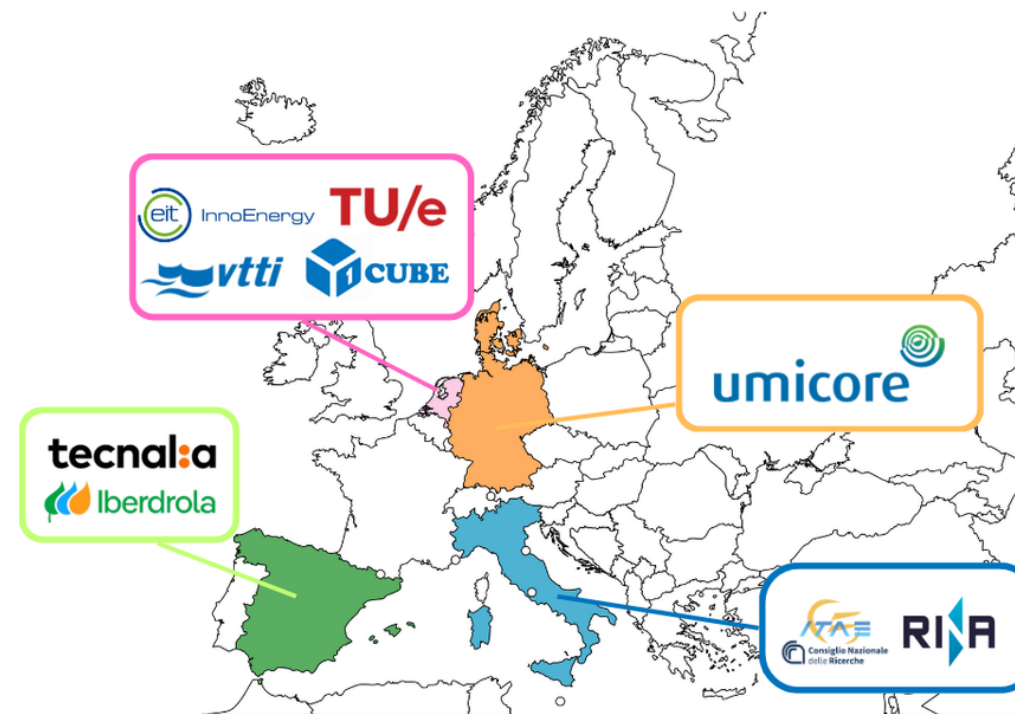
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### 3. Participants & Consortium synergies



- 9 partners from 4 countries.
- 6 SME/IND + 3 RTD partners (44% SME/IND; 28% SME)
- ANDREA H has an interdisciplinary approach including chemistry, material design, engineering, modelling, manufacturing, safety, business and economics.
  - companies specialised in materials development (UMI), energy multinational companies (IBER) and energy storage provider (VTTI).
  - top-level European Research Public/private Institutes and Universities will collaborate (TUE, CNR and TEC) to turn ANDREA H objectives into results that can later be scaled-up and exploited
  - LCA, LCC and HSA will be performed by RINA-C and tailored dissemination and communication strategies led by ICUBE.





# 4. Overall planning



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WP	Tasks	start	end	Year 1												Year 2												Year 3												Year 4											
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	1.1 Market Analysis and Value Proposition	1	12	[Task bar]																																															
	1.2 IPR management and exploitation strategy	1	48	[Task bar]																																															
	1.3 Business Modeling and Go-To-Market Strategy	13	48	[Task bar]																																															
	1.4 Regulatory and standardization pathways	13	48	[Task bar]																																															
2	2.1 Technology requirements	1	3	[Task bar]																																															
	2.2 Modelling of key components and processes for short-term storage	1	24	[Task bar]																																															
3	3.1 Lab-scale NH <sub>3</sub> cracking catalyst (TRL3): Advanced synthesis, characterization, performance evaluation and identification of the promising formulation	1	18	[Task bar]																																															
	3.2 Small scale catalysts based on commercial OCFs / 3D printed POCS	1	24	[Task bar]																																															
	3.3 Development and characterization of H <sub>2</sub> selective CMSMs	1	42	[Task bar]																																															
	3.4 Development and characterization of sorbents for hydrogen polishing	1	36	[Task bar]																																															
	3.5 Upscaling of new key materials and components for the demonstration plant (TRL 5): ammonia decomposition catalyst, OCF and/or 3D printed POCS	20	42	[Task bar]																																															
	3.6 Catalytic performance of the prepared POCS catalysts integrated with a membrane [TUE, CNR, TEC] at bench-scale (TRL4)	13	46	[Task bar]																																															
4	4.1 Design and fabrication of membrane reactor and system	16	40	[Task bar]																																															
	4.3 TRL5 testing of CMRs for ammonia cracking	41	48	[Task bar]																																															
5	5.1 Life Cycle Assessment via LCC/S-LCA/LCA approach	6	48	[Task bar]																																															
	5.2 Health and Safety analysis of the systems	6	30	[Task bar]																																															
	5.3 Techno-economic feasibility at full-scale and replication studies	18	48	[Task bar]																																															
	5.4 Social acceptance and market readiness for ANDREAH solution	30	48	[Task bar]																																															
6	6.1 Dissemination and communication plan	1	48	[Task bar]																																															
	6.2 Dissemination and communication tools	1	48	[Task bar]																																															
	6.3 Workshop, courses and guided visits	1	48	[Task bar]																																															
7	7.1 Overall administrative, contractual and financial reporting	1	48	[Task bar]																																															
	7.2 Consortium management	1	48	[Task bar]																																															
	7.3 Data Management Plan	1	48	[Task bar]																																															

54 Deliverables - 7 Milestones



- **ER1: Advanced Ammonia decomposition system** based on Membrane Reactor technology for hydrogen production.
- **ER2: Innovative environmentally friendly catalyst materials** that can be used at much lower temperatures compared to conventional ammonia decomposition.
- **ER3: Innovative carbon membranes** for selective separation of hydrogen during the gas phase production process.
- **ER4: Recipes for the activation of OCFs and 3D-printed POCSs** with the catalyst.
- **ER5: Novel sorbents for polishing** the H<sub>2</sub> recovered by the membranes



**KER1: Advanced NH<sub>3</sub> cracking system based on Membrane Reactor technology for H<sub>2</sub> production.**

**Main partner:** TUE/TEC/CNR (Participates: IBER, UMI, VTTI, KIC )

**Value proposition:** Ammonia decomposition system based on advance catalysts and membranes integrated into catalytic membrane reactor coupled with sorbent-based polishing technology.




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# Ammonia based membrane reactor for green Hydrogen production



*Thank you for your attention*



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